LIGO/Virgo Status, Plans, Data Analysis, Data Release Policies

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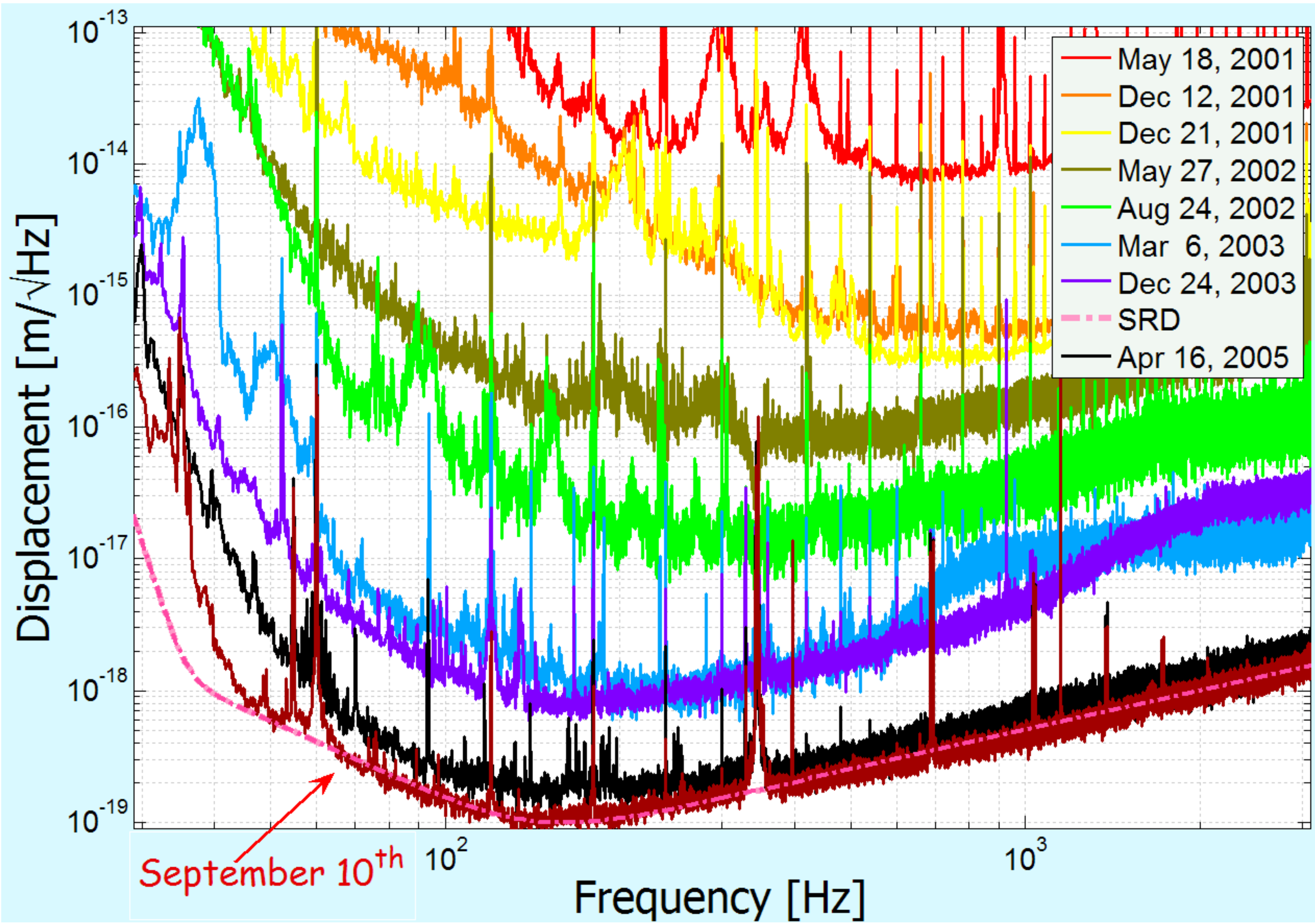
For the LIGO Scientific Collaboration and
the Virgo Collaboration

Panel discussion, Princeton University, April 30 2012

Connecting the Electromagnetic and Gravitational Wave Skies in the Era of Advanced LIGO

For reference: initial LIGO commissioning



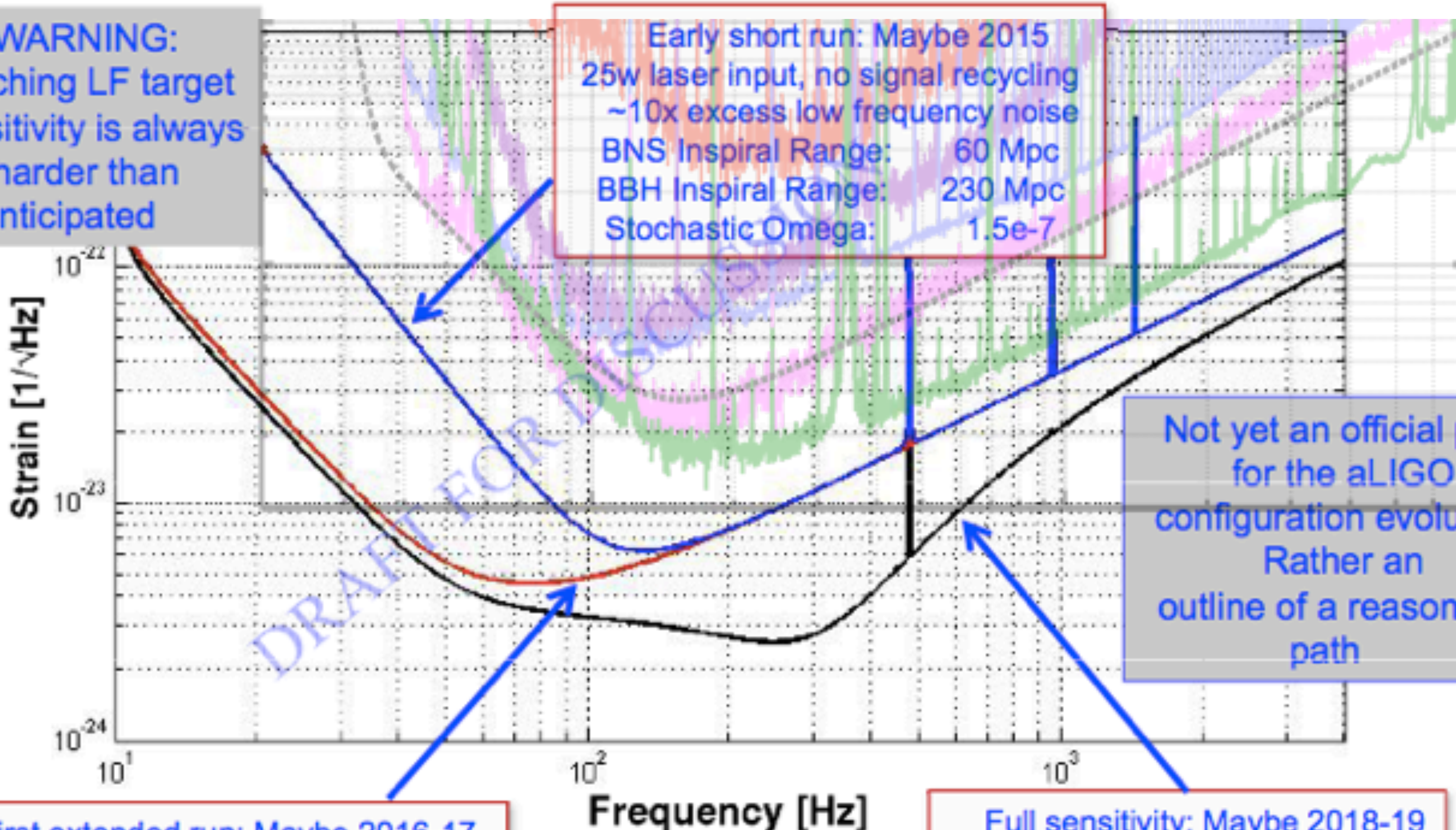
aLIGO detectors timeline

- 2012 Start integrated testing (one arm lock at LHO, corner Michelson at LLO)
- 2013 L1 interferometer begins commissioning.
- 2014 H1 interferometer begins commissioning.
- 2015 All interferometers are accepted (and end of aLIGO project - operations and commissioning follows)
  - "Accepted" means that the IFOs can lock for two hours
  - Commissioning will be needed to go beyond this to design sensitivity
- Virgo plans to begin locking V1 in ~ 2015.

aLIGO possible sensitivity curves, science runs

WARNING: reaching LF target sensitivity is always harder than anticipated

Early short run: Maybe 2015
25w laser input, no signal recycling
~10x excess low frequency noise
BNS Inspiral Range: 60 Mpc
BBH Inspiral Range: 230 Mpc
Stochastic Omega: 1.5e-7

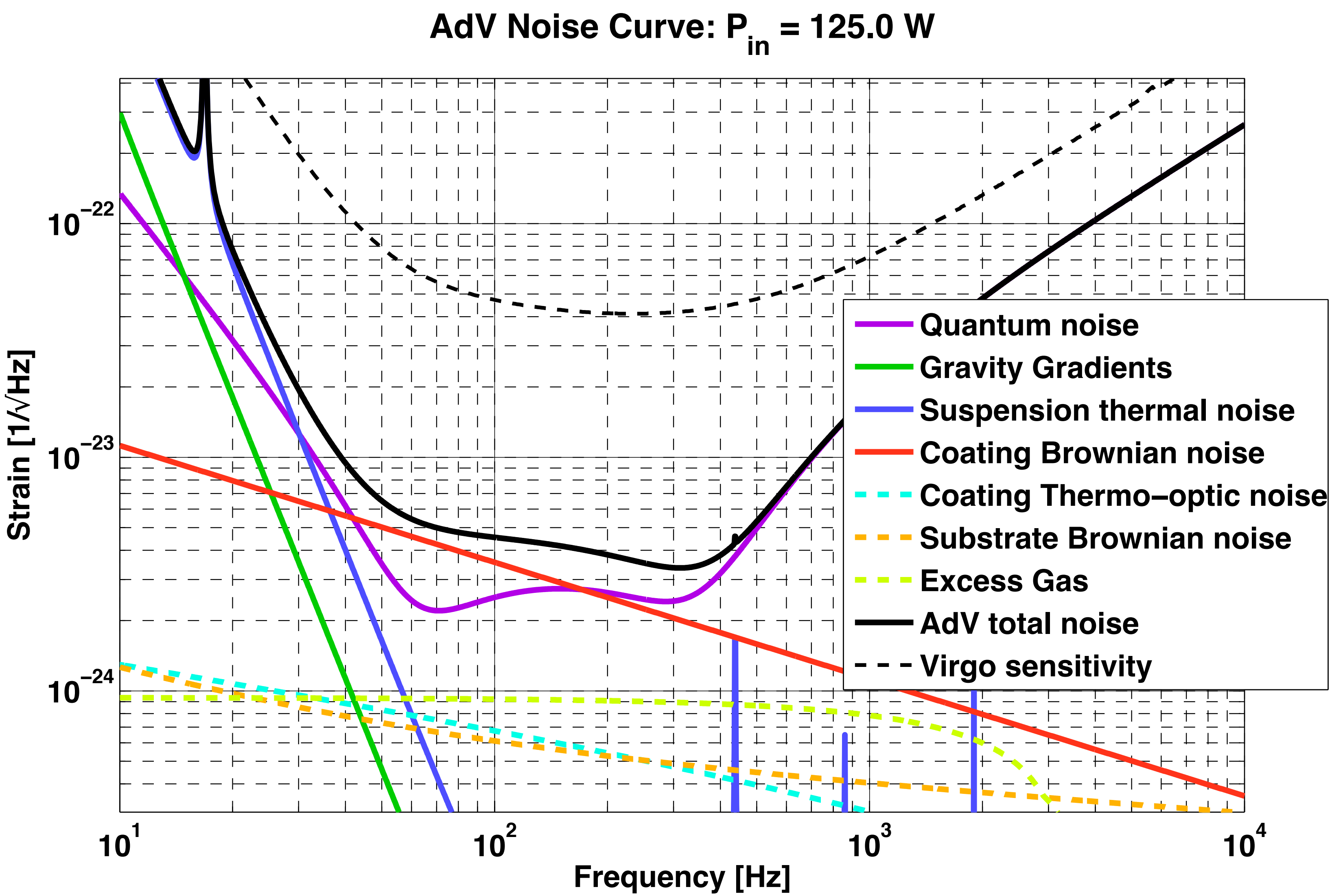


Not yet an official plan for the aLIGO configuration evolution! Rather an outline of a reasonable path

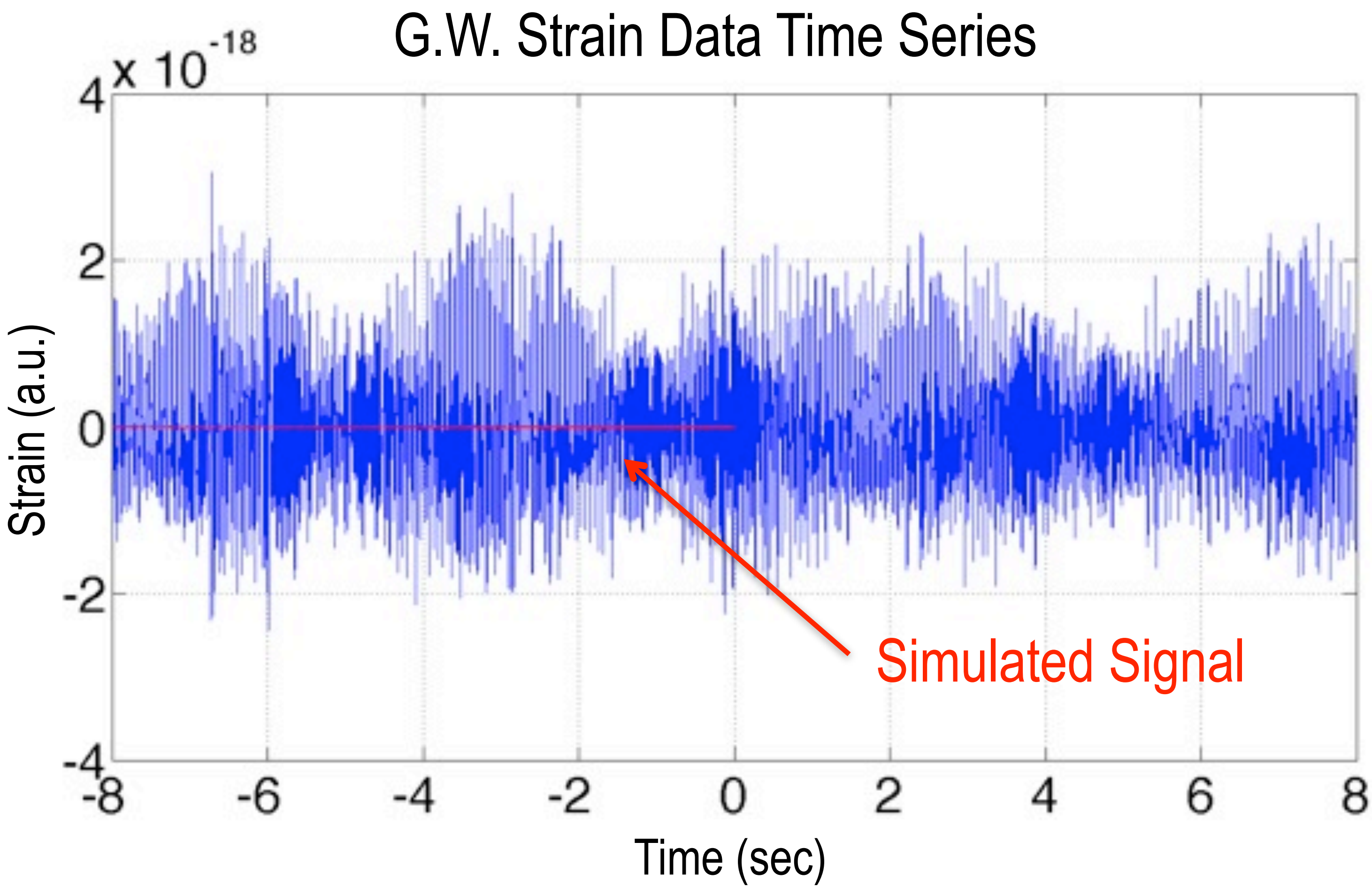
First extended run: Maybe 2016-17
25w laser input, no signal recycling
BNS: 140 Mpc
BBH: 1400 Mpc
Stochastic: 3e-9

Full sensitivity: Maybe 2018-19
125w laser input, signal recycling
BNS Inspiral Range: 200 Mpc
BBH Inspiral Range: 1600 Mpc
Stochastic Omega: 2.3e-9

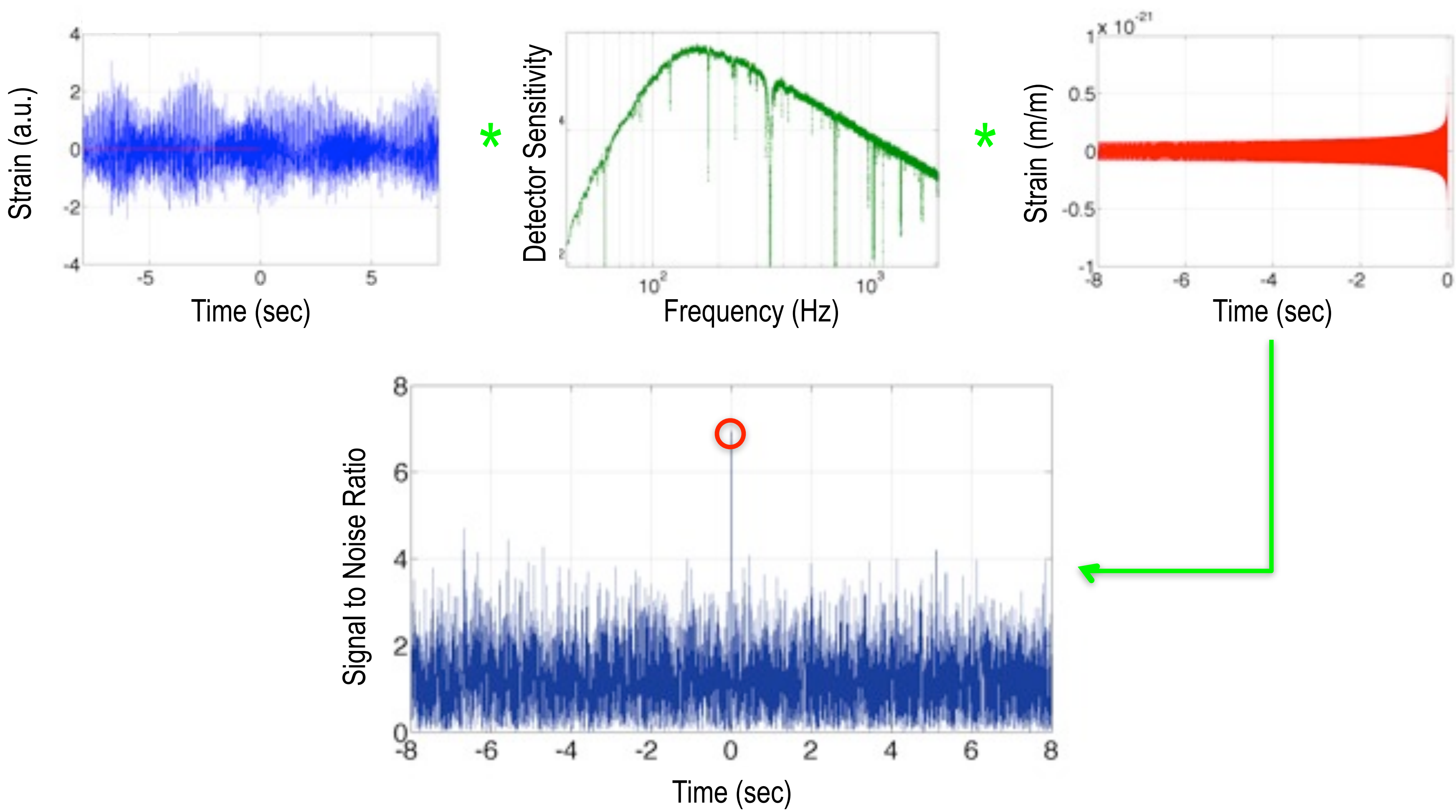
AdVirgo Design Sensitivity



Injected Signal in LIGO Data



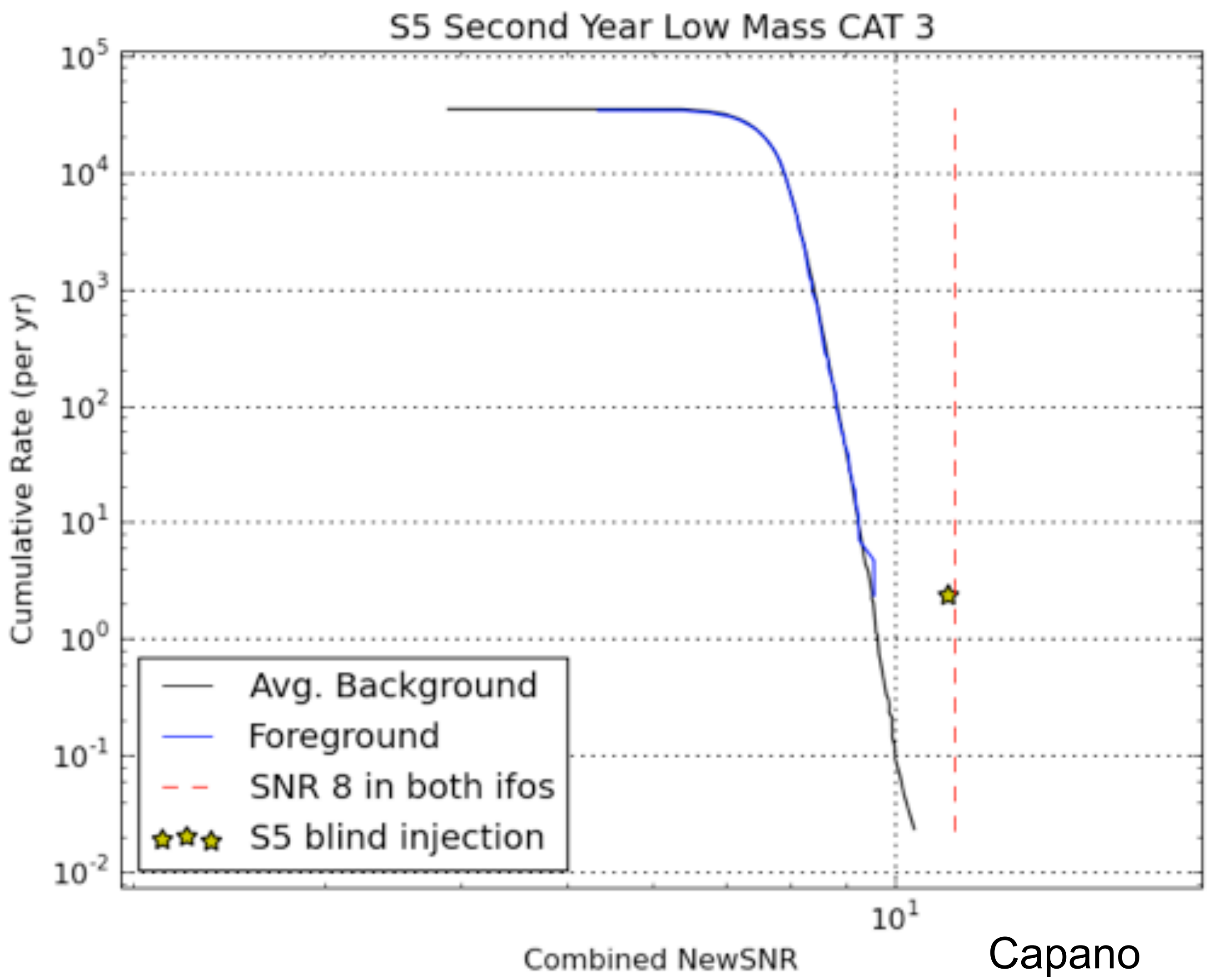
Matched filtering to detect signals



Injected BNS signal detected with only L1 and H1

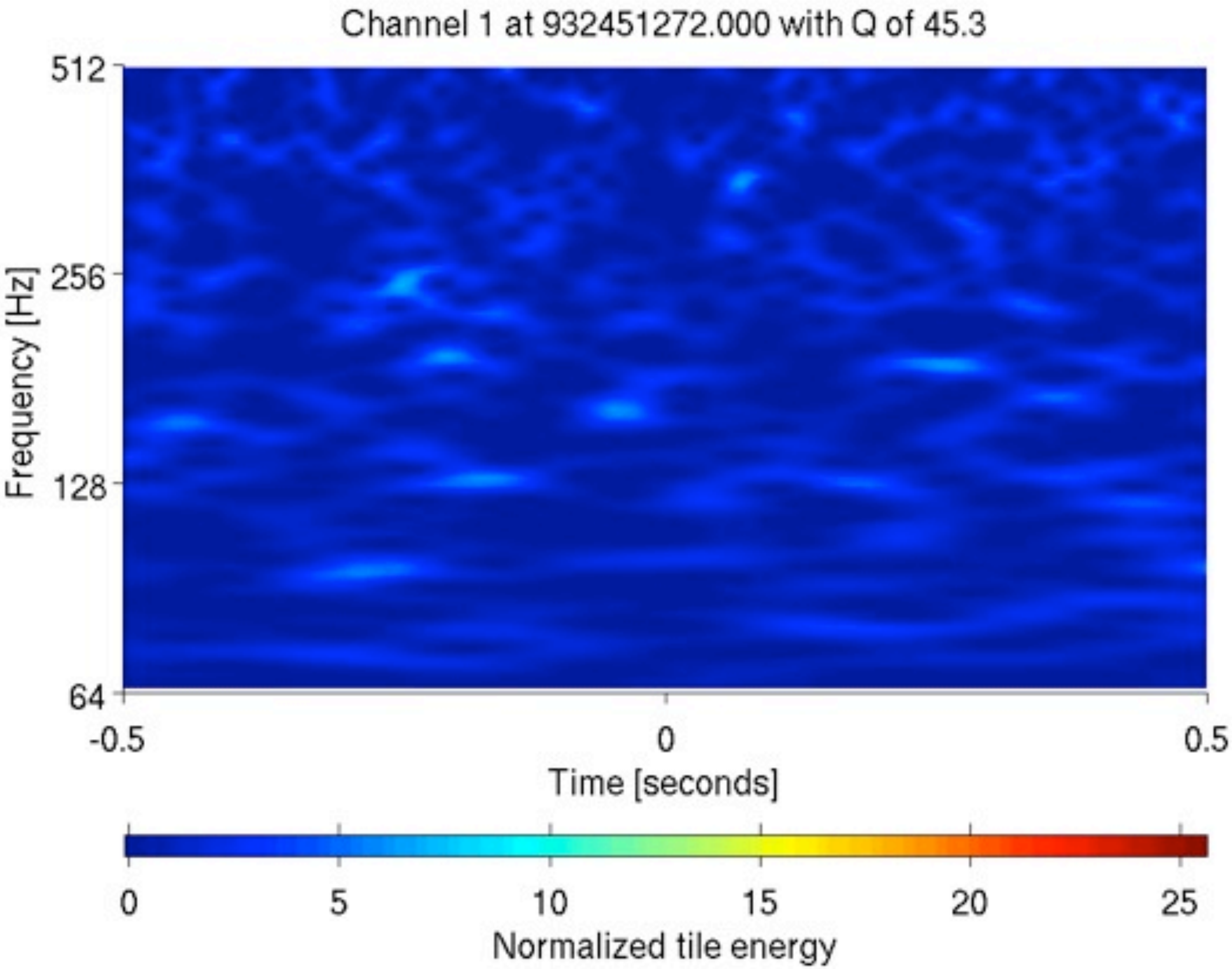
S5 conditions for good statistics:

* Low masses (NS/NS)
* CAT3 vetoes
* Chi-squared weighting (NewSNR)



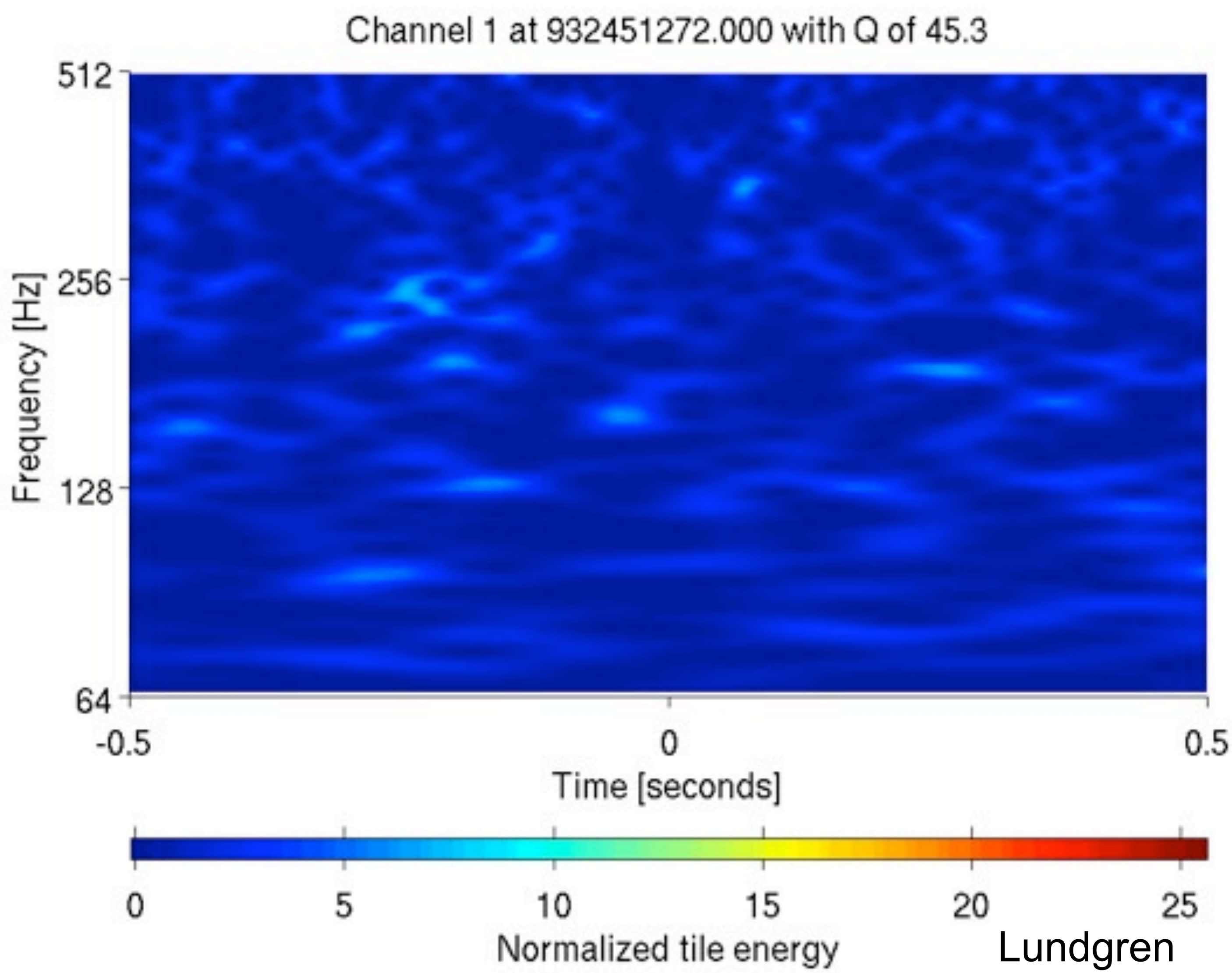
Capano

BNS at SNR 8 in iLIGO



Lundgren

BNS at SNR 12 in iLIGO



Lundgren

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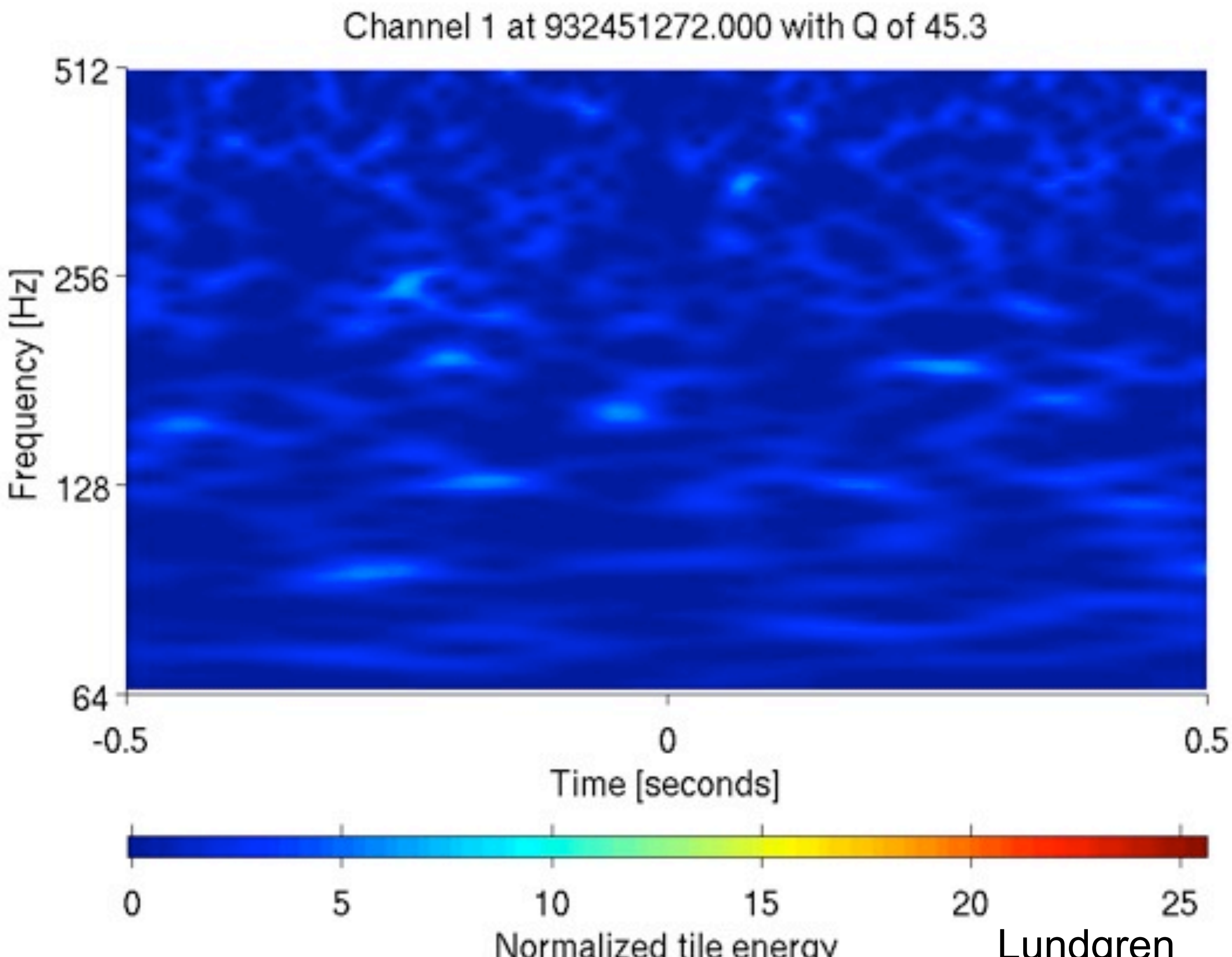
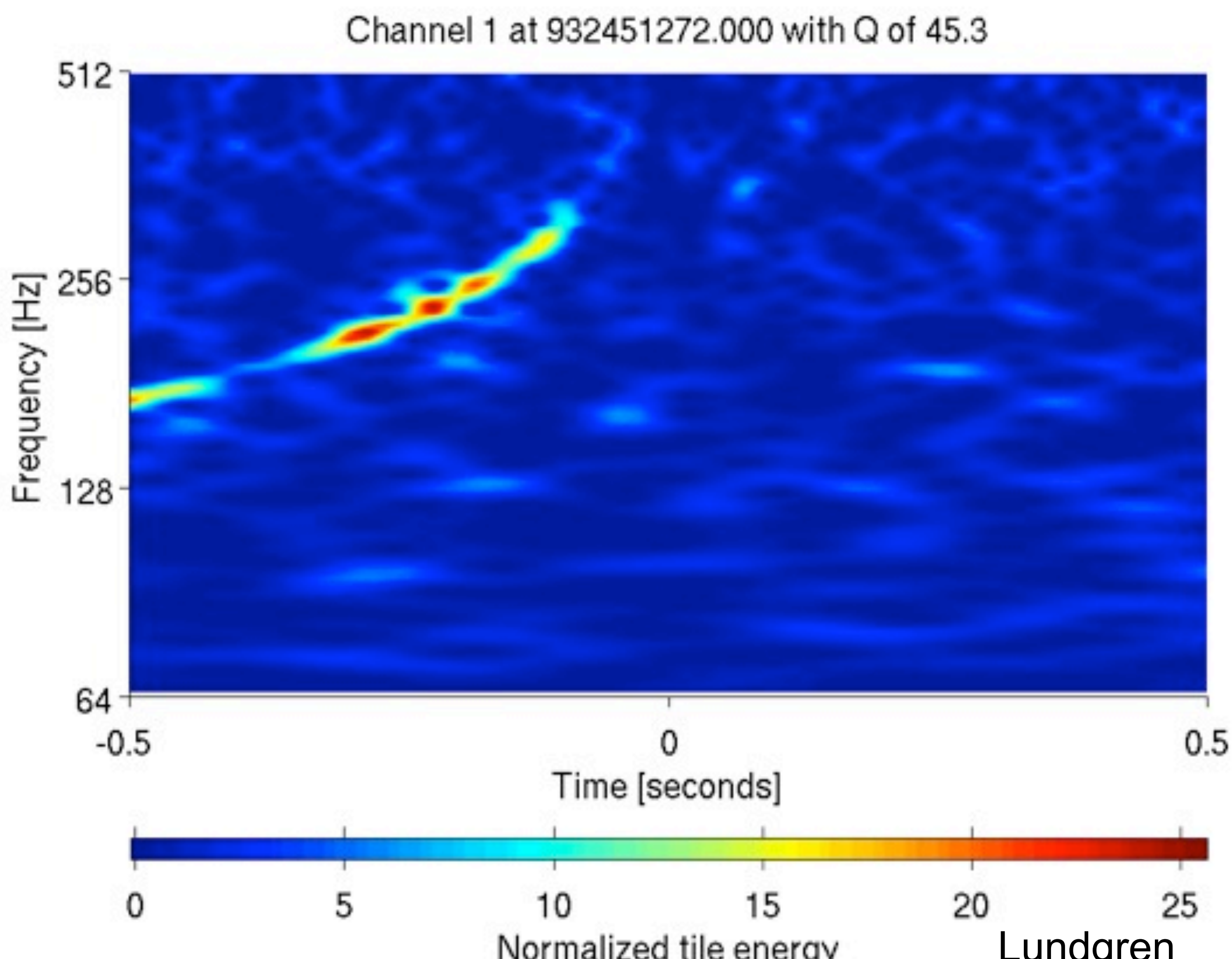


Lundgren

BNS at SNR 12 in iLIGO



Lundgren

Detection rates?

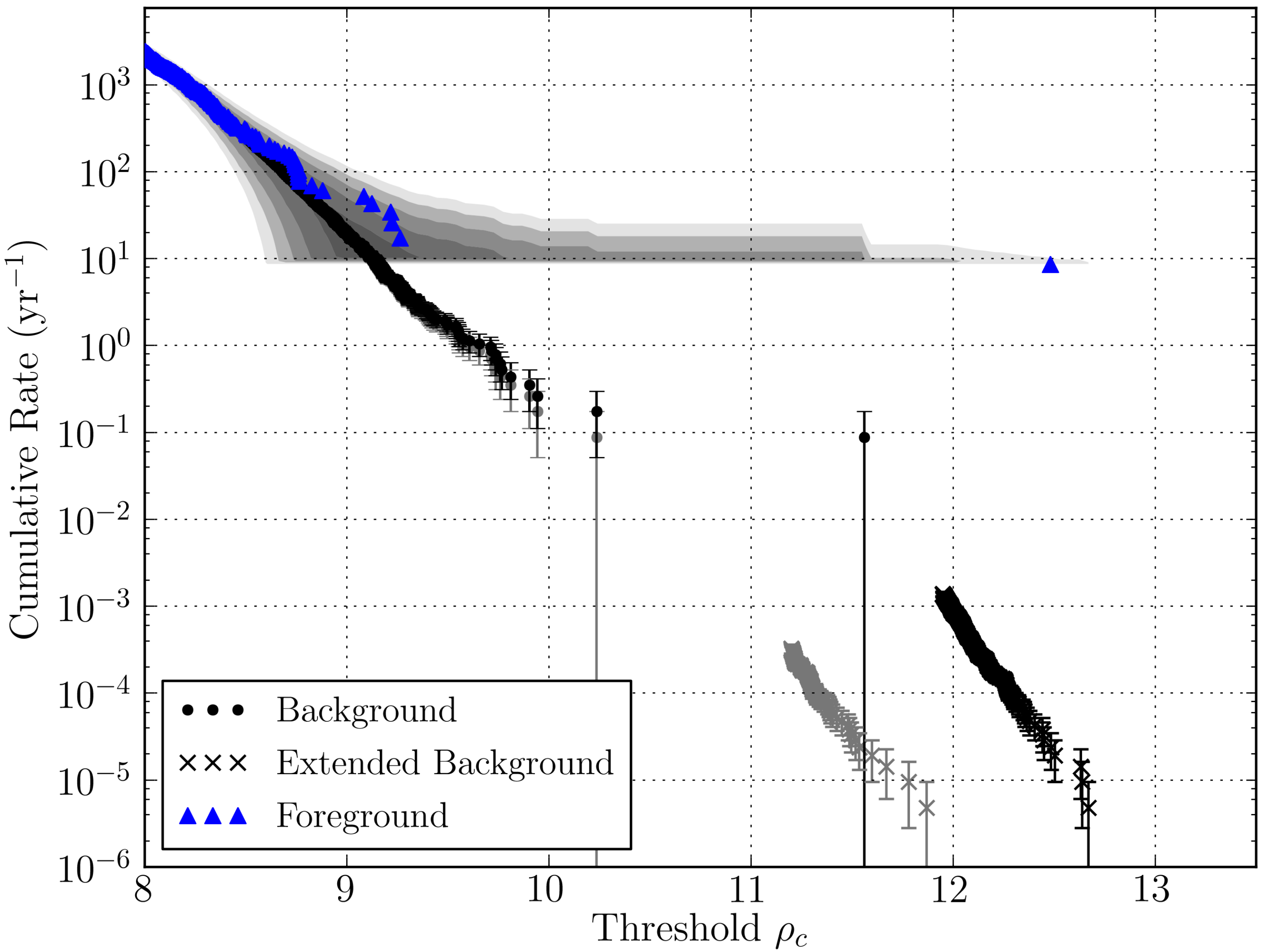
- For aLIGO BNS average sensitivity ~200 Mpc, BNS "realistic" rate is 40 per calendar year.
- Rate scales with volume:
  - for 60 Mpc, 0.3/yr
  - For 140 Mpc, 13/yr
- Caveats:
  - Assumes single detector SNR~8, but needs at least two detectors.
  - Duty cycles for coincident detectors is ~50%.
  - In S6, a coincident trigger with SNR~8*1.41=11 had a FAR 10^{-3} -10^{-4} /yr, times a trials factor 10.1103/PhysRevD.85.082002 Cite as: arXiv:1111.7314v4

Table 5. Detection rates for compact binary coalescence sources.

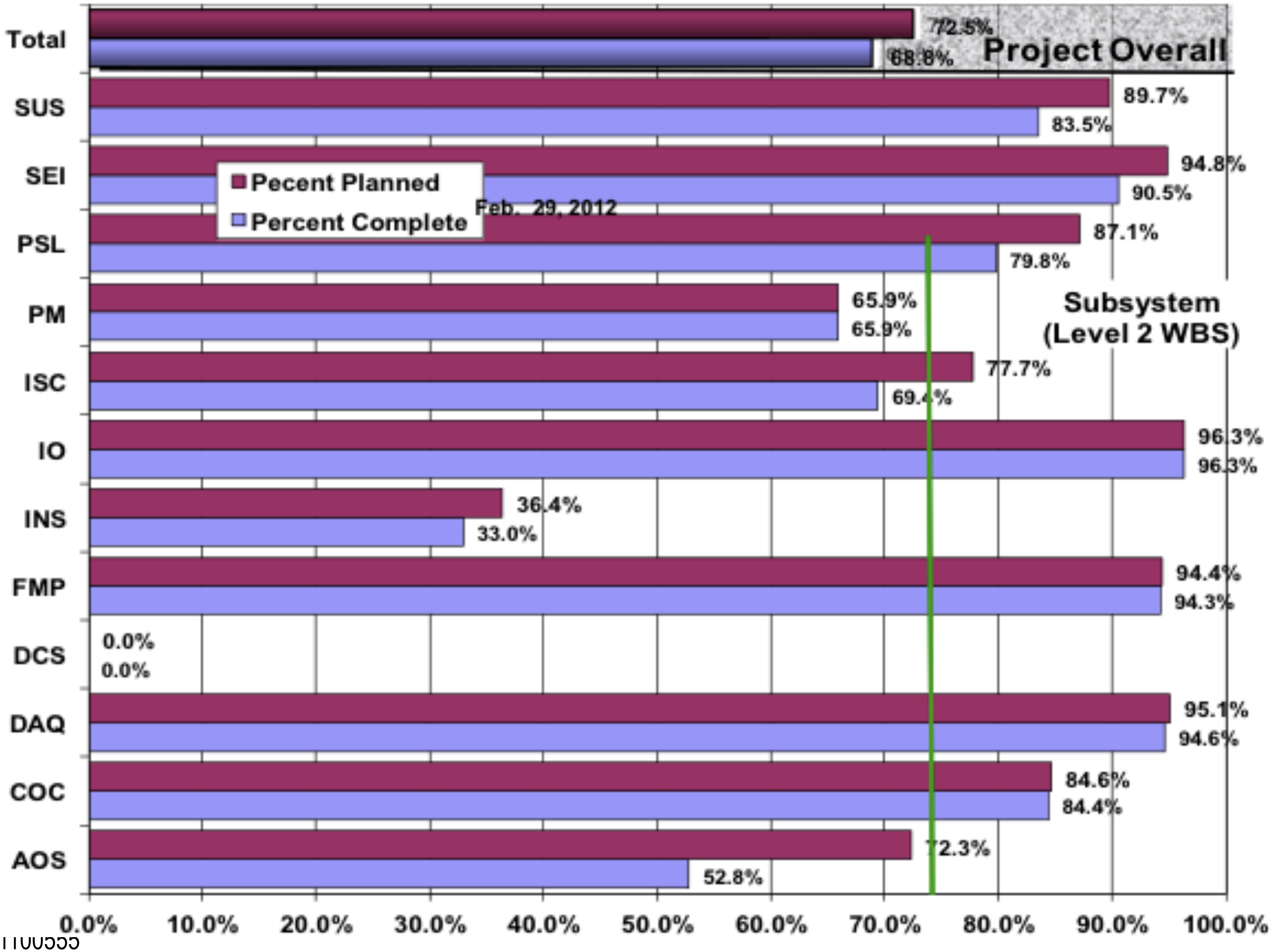
IFO	Source[a]	$\dot{N}_{low}$ yr^{-1}	$\dot{N}_{re}$ yr^{-1}	$\dot{N}_{high}$ yr^{-1}	$\dot{N}_{max}$ yr^{-1}
Initial	NS–NS	2×10^{-4}	0.02	0.2	0.6
	NS–BH	7×10^{-5}	0.004	0.1	
	BH–BH	2×10^{-4}	0.007	0.5	
	IMRI into IMBH			<0.001[b]	0.01[c]
	IMBH-IMBH			10^{-4}[d]	10^{-3}[e]
Advanced	NS–NS	0.4	40	400	1000
	NS–BH	0.2	10	300	
	BH–BH	0.4	20	1000	
	IMRI into IMBH			10[b]	300[c]
	IMBH-IMBH			0.1[d]	1[e]

Class. Quant. Grav. **27**, 173001 (2010)

S6 Blind Injection



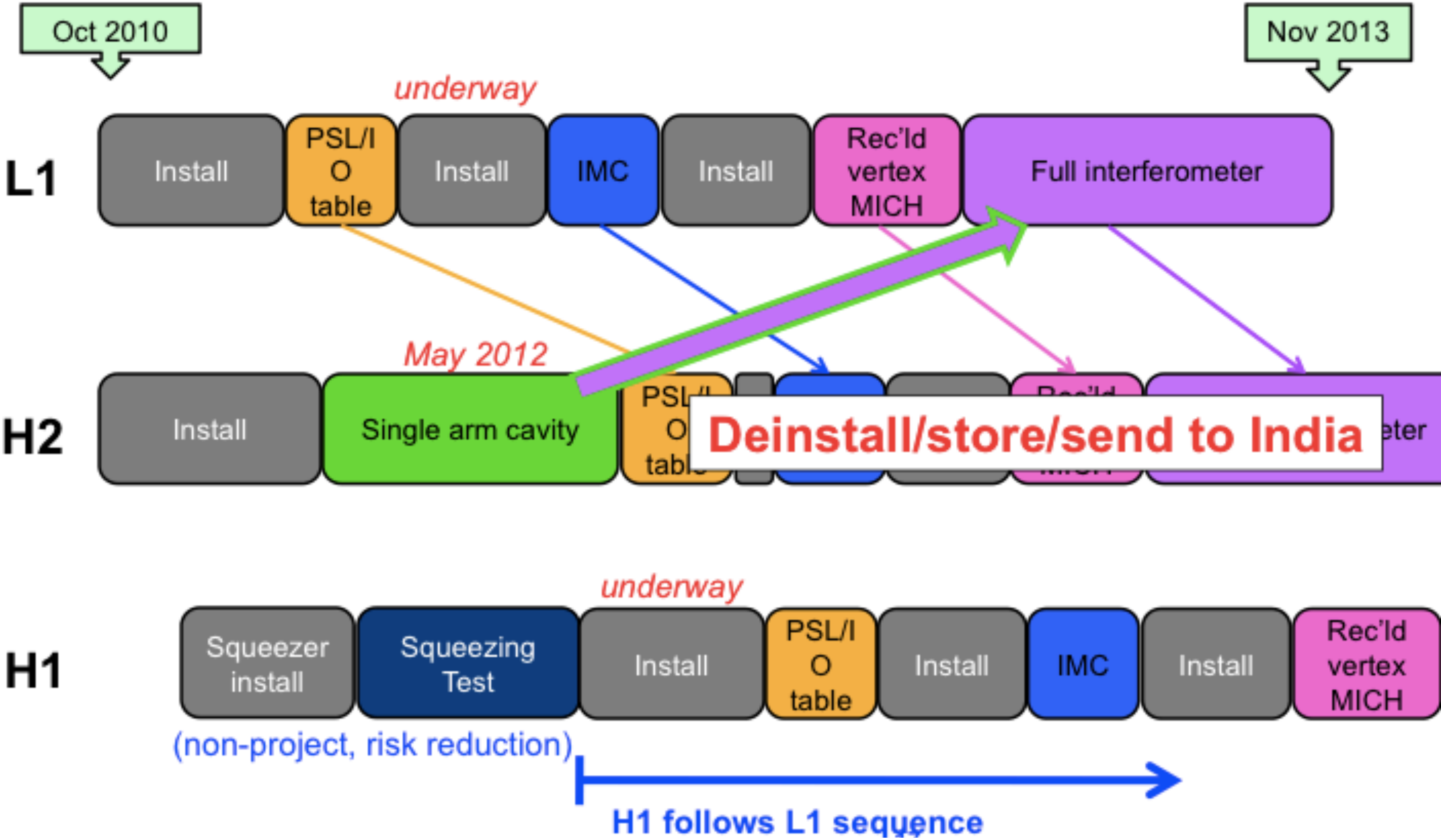
aLIGO Project Status Feb, 2012

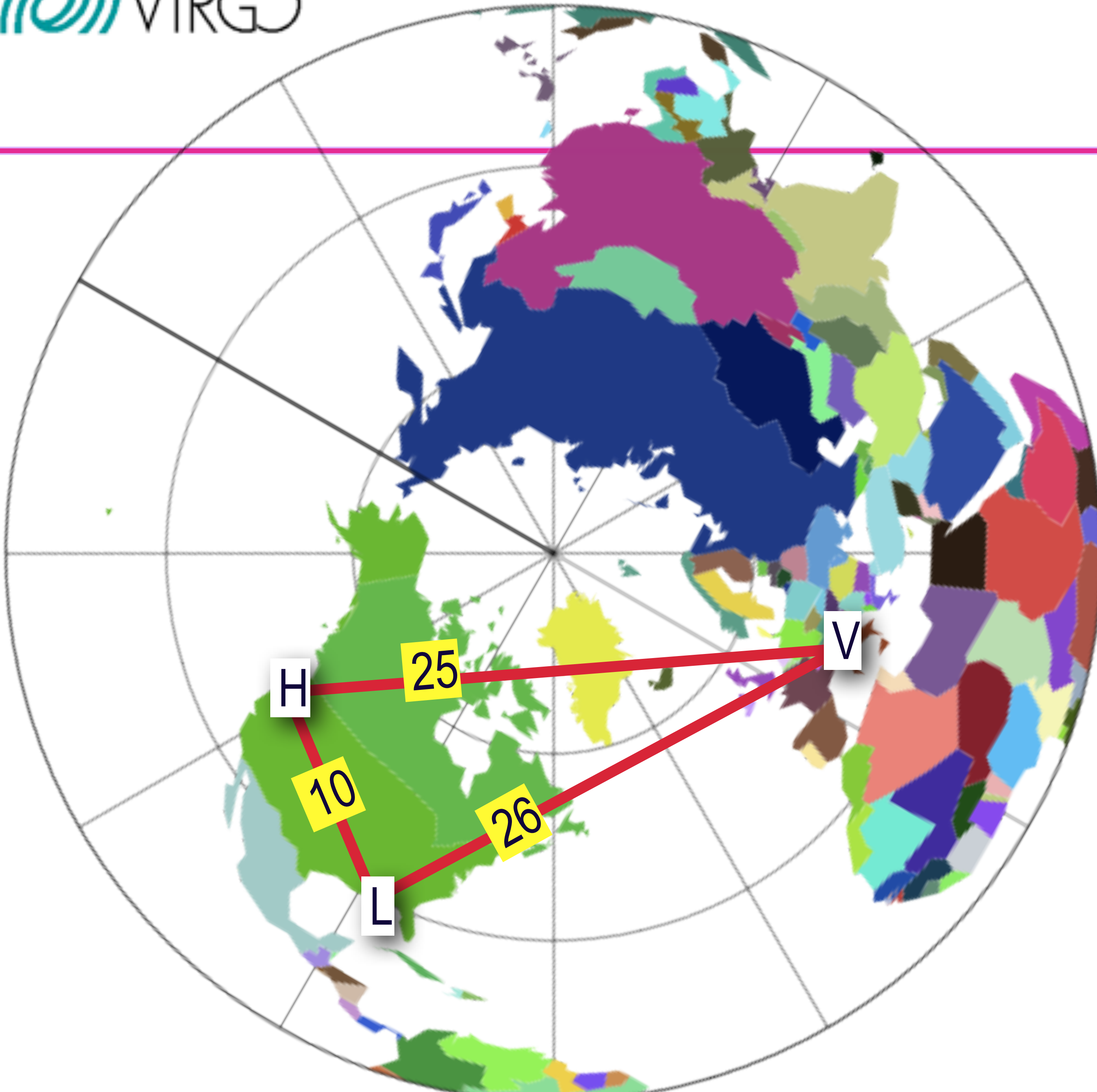


LIGO India Timeline (subject to NSF/NSB approval)

aLIGO-USA	Planned LIGO-India
Oct 2011: Installation start	
May 2012: Integrated test start	
Jul 2012: corner Michelson testing	Mid 2012: Project start
July 2013: All installation complete	Mid 2013: Contractors selected
Nov 2014: All interferometers accepted	Mid 2014: Start site development
2015: Possible first science run	2015: Construction well underway
2017: Higher sensitivity runs	2017: Ship instrument to India
	2018: Facility ready, start install
	2019: installation complete
	Early 2020: interferometer accepted
	Mid 2020: First science run

aLIGO Installation Schedule

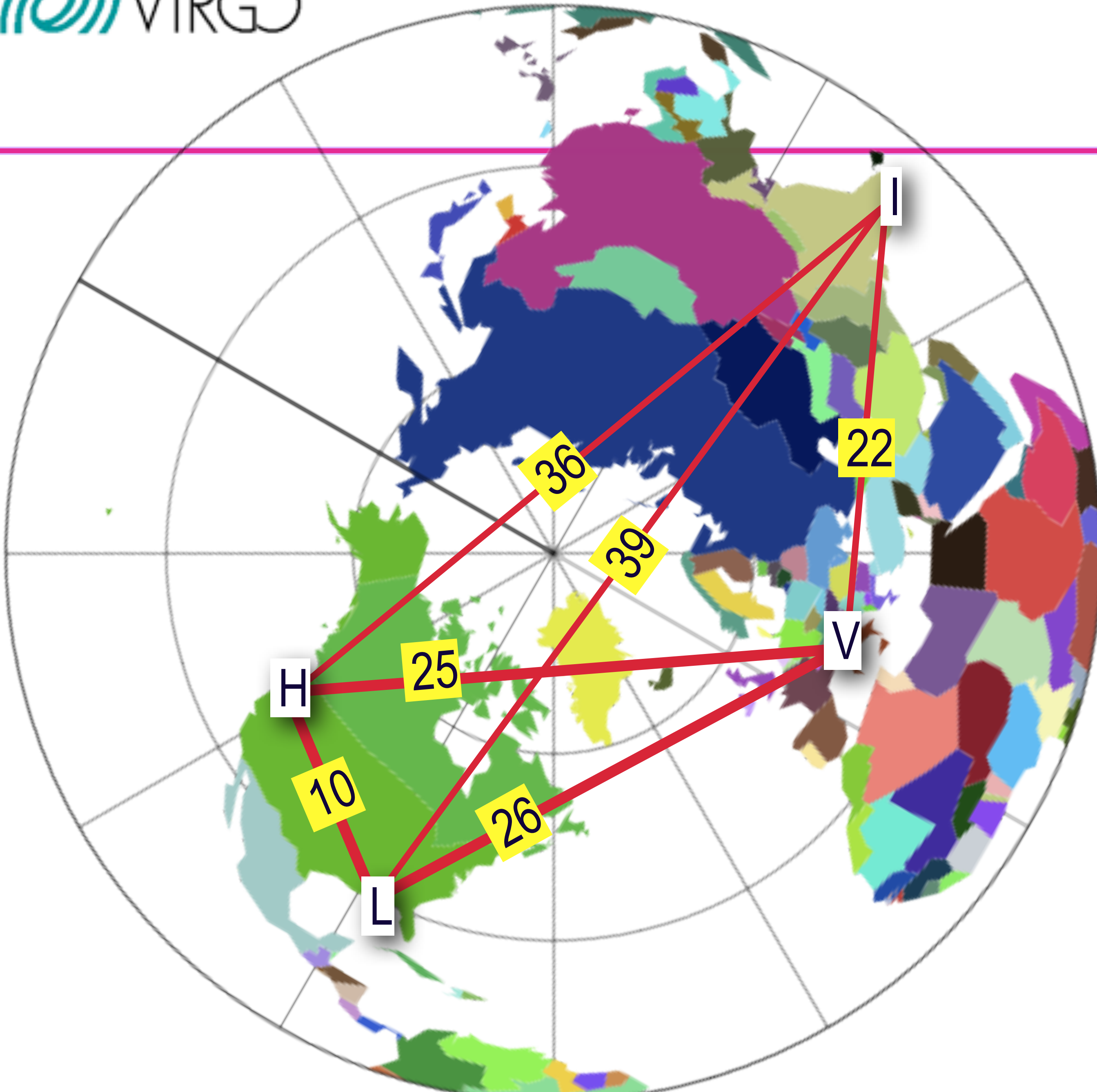




Detector Networks

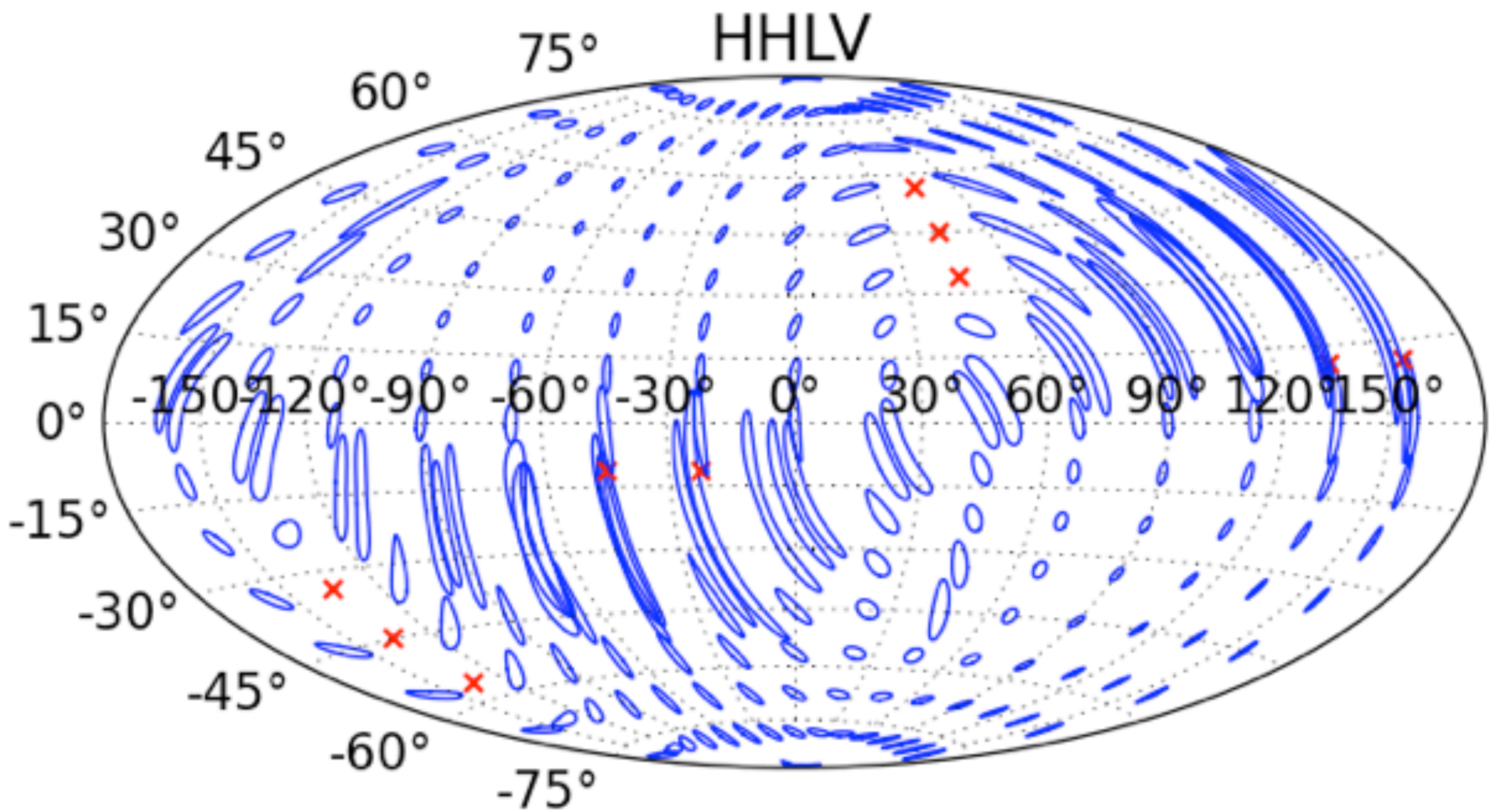
Baselines in light travel time (ms)

Detector Networks



Baselines in light travel time (ms)

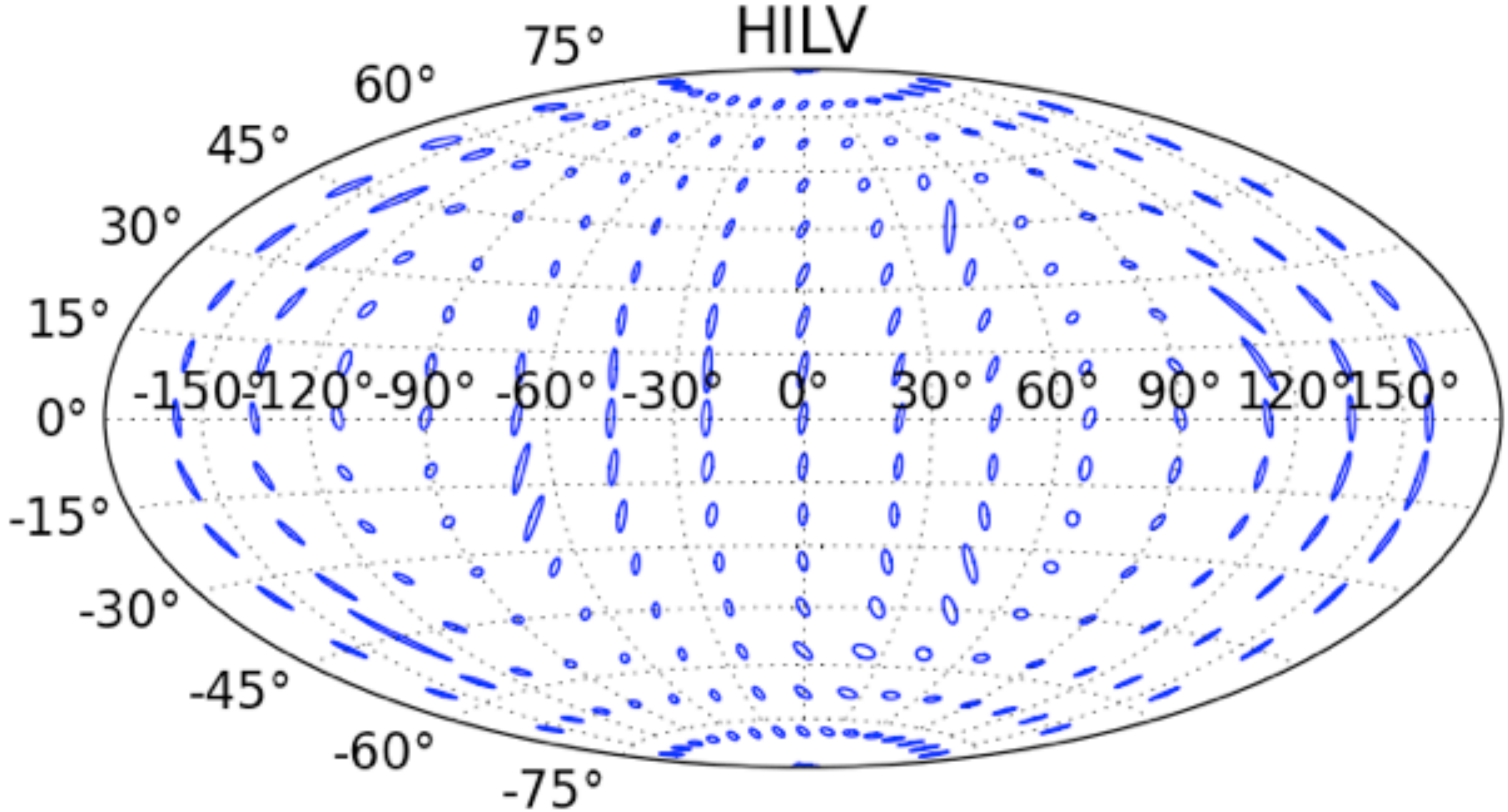
Sky Localization Error Ellipses



Red crosses denote regions where the network has blind spots

Fairhurst 2011

Sky Localization Error Ellipses



Fairhurst 2011

LSC AND VIRGO POLICY ON RELEASING GRAVITATIONAL WAVE TRIGGERS TO THE PUBLIC IN THE ADVANCED DETECTORS ERA

The LSC and Virgo recognize the great potential benefits of multi-messenger observations, including rapid electromagnetic follow-up observations of GW triggers. Both Collaborations (the LSC and Virgo) will partner with astronomers to carry out an inclusive observing campaign for potentially interesting GW triggers, with MoUs to ensure coordination and confidentiality of the information. They are open to all requests from interested astronomers or astronomy projects which want to become partners through signing an MoU. They encourage colleagues to help set up and organize this effort in an efficient way to guarantee the best science can be done with gravitational wave triggers.

After the published discovery of gravitational waves with data fromLSC and/or Virgo detectors, both the LSC and Virgo will begin releasing especially significant triggers promptly to the entire scientific community to enable a wider range of follow-up observations. This will take effect after the Collaborations have published papers (or a paper) about 4 GW events, at which time a detection rate can be reasonably estimated. The releases will be done as promptly as possible, within an hour of the detected transient if feasible. Initially, the released triggers will be those which have an estimated false alarm rate smaller than 1 per 100 years.

Partners who have signed an MoU with the LSC and Virgo will have access to GW triggers with a lower significance threshold and/or lower latency, according to the terms of the MoU, in order to carry out a more systematic joint observing campaign and combined interpretation of the results.

Throughout the Advanced Detectors era, the LSC and Virgo will release appropriate segments of data from operating detectors corresponding to detected gravitational waves presented in LSC/Virgo authored publications, at the time of the publication, including the first claimed detection of gravitational waves.

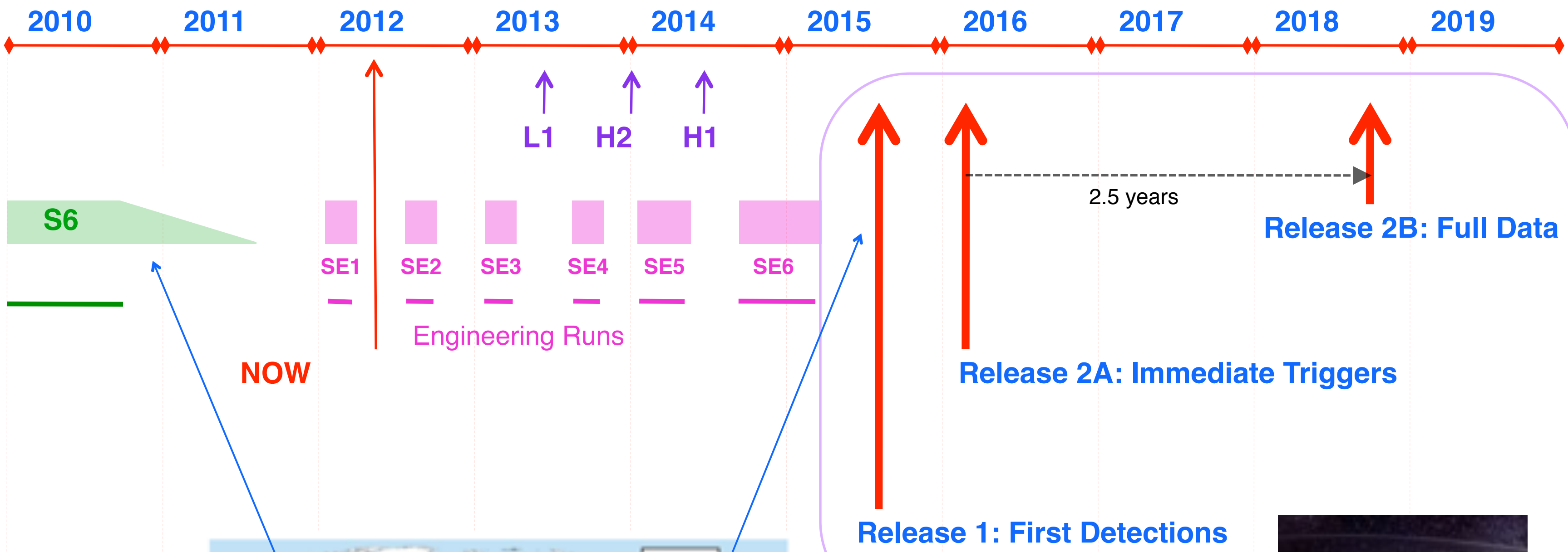
The agreement has been reached by the two collaborations as detailed in this document, and will be submitted to the Virgo funding agencies in the coming months.

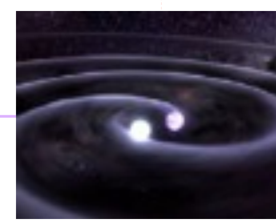
The text of this policy was approved by LSC Council on March 21, 2012.

The LIGO Data Management Policy LIGO-M1000066 will take precedence in how LIGO data are released should this policy and the LIGO DMP be in potential conflict.

(LIGO) Open data release plan

LIGO data management plan (public) LIGO-M1000066 (dcc.ligo.org)





Dates are "guaranteed no earlier"